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Japan Report

SCIENCE AND TECHNOLOGY

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JAPAN REPORT

SCIENCE AND TECHNOLOGY

CONTENTS

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BIOTECHNOLOGY

BIOLOGICAL PEST CONTROL BY ENTOMOGENOUS NEMATODES DISCUSSED

Tokyo BIO INDUSTRY in Japanese Jun 86 pp 5-12

[Article by Satoshi Yamanaka, assistant chief researcher of Tokyo Research Institute of SDS Bio-Tech Co., Ltd.; first paragraph is editorial introduction]

[Text] It is expected that the entomogenous nematode will be developed as a new bioagricultural chemical in the future, because it shows high insecticidal power against the larva and imago of about 250 kinds of insects, having a wide parasitic range. This entomogenous nematode will be affected by the external environment because it is a living organism. But unlike chemical insecticides, it is effective on noxious insects which live in places beyond the reach of insecticides. This is because it has the capacity of searching for insects and is parasitic on them. This paper will introduce research on the insecticidal mechanism of entomogenous nematodes, method of cultivating them, and future evolution of this research.

1. Preface

Prevention of breeding and extermination of noxious insects can be cited as among the important methods of enhancing the productivity of farm products. This method is taken with a view to prevent farm products from being damaged by noxious insects and being infected with diseases, keeping these farm crops from decreasing, and enhancing the quality of farm products. Most of the countries have used organic-synthetic agricultural chemicals as a general method of attaining these purposes since World War II. Many organic-synthetic agricultural chemicals have been developed up to now, and have contributed greatly to agricultural production. However, the use of some of these agriculutral chemicals has been stopped because of safety problems. The remainder have been strictly controlled in accordance with safety standards. In addition, the use of some has eventually been stopped, because resistivity of noxious insects has surpassed the effect of some agricultural chemicals. Apart from the development of organic-synthetic agricultural chemicals, since ancient times, human beings have conducted research on prevention of breeding and extermination of noxious insects according to scattering method and pasturage of natural enemies, parasites, pathogenic bacteria, etc. This research has been conducted from knowledge obtained by understanding the cause of death of insects due to diseases or parasitism. The oldest methods of biologically preventing the breeding of noxious insects and exterminating them,

have been recorded as data on the prevention of breeding and extermination of noxious insects of citrus fruits. This method was taken using Oecophylla smaragdina in Chinese ancient times. According to the record, the method by Keigan in the Shin era in 304. Although it seems that this steady research was inconspicuous for a period after World War II due to excellent effectiveness of organic-synthetic agricultural chemicals, research on cultivation of a large number of useful living organisms has again enthusiastically been conducted while riding the crest of the recent biotechnology boom. These are called, "Biological Agricultural Chemicals" or "Bioagricultural Chemicals."

Now, we do not deny the use of organic-synthetic agricultural chemicals, but want to say that it is important to use not only these chemicals but also conventional biological agricultural chemicals which have been inconspicuous due to the effectiveness of the organic-synthetic agricultural chemicals. The effective use of both chemicals will further develop agriculture in the future.

Although it is difficult to define "Biological Agricultural Chemicals" or "Bioagricultural Chemicals," it can be considered that bioagricultural chemicals includes a wide range of biological agricultural chemicals and biochemical agricultural chemicals. Biological agricultural chemicals means a living biological solid used directly as an agricultural chemical, and depending on the living organism used, it can be classified into two kinds, i.e., a microorganism group including virus, bacteria, filamentous fungi, nematodes, etc., and a small animal group, including parasitical bees, ticks, etc., used as natural enemies.

The natural physiologically active substance originates in living organisms such as toxic and sex pheromones which act on antibiotics and insects. Biochemical agricultural chemicals mean such natural physically active substances or derivatives.

We are conducting research on prevention of breeding and extermination of noxious insects using entomogenous nematodes. This research belongs to biological agricultural chemicals. Generally speaking, entomogenous nematodes can be broadly classified into the following three items:

(1) Nematodes which are parasitic on specific insects and which are symbiotically related to them.

(2) Nematodes which are parasitic on specific insects and which kill them.

(3) Nematodes which are parasitic on unspecific insects and which kill them.

We are conducting research on nematodes which belong to the Neoaplectana and Heterorhabditis genuses. These genuses also belong to item (3) above. This nematode hereafter will be called "Entomogenous Nematode" in a narrow sense. This entomogenous nematode is characterized by its wide host-range and strong insecticidal activity. The entomogenous nematode is a biological agricultural chemical which will probably be put to practical use. A method of economically breeding a large number of entomogenous nematodes has been established.

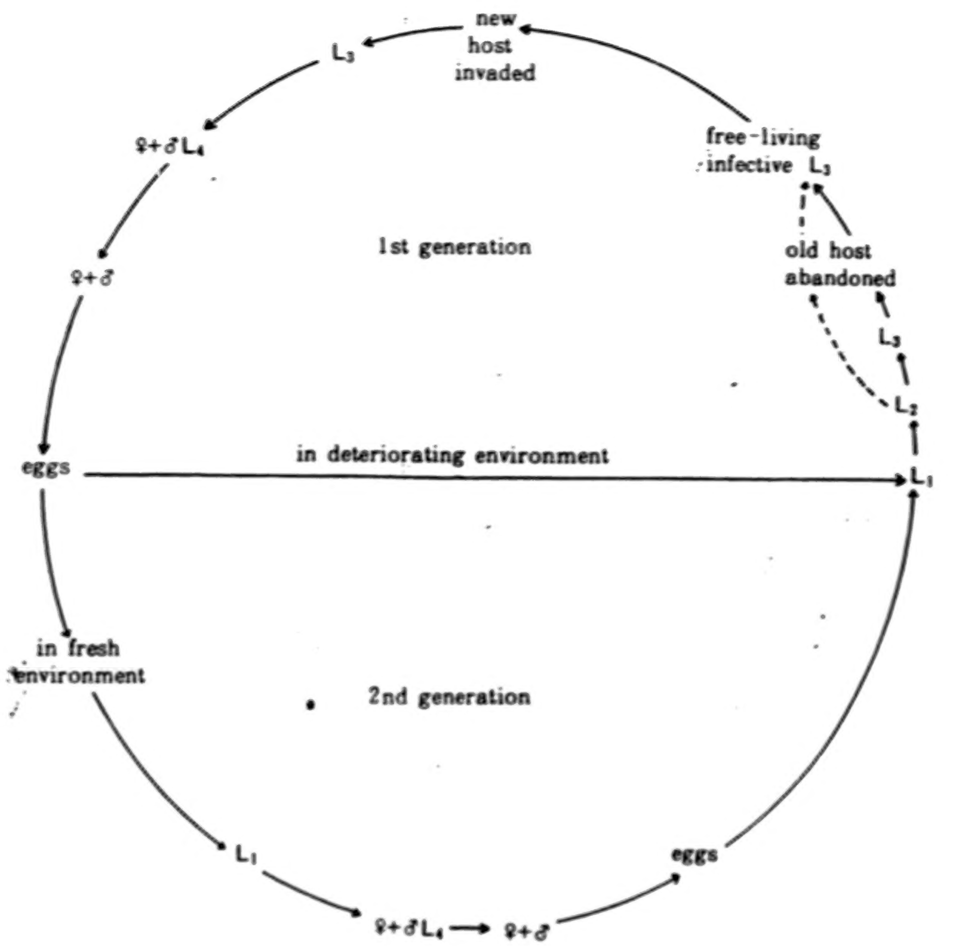

Figure 1(a). Life Cycle in Insect Host of N. bibiouis

2. Characteristics of Entomogenous Nematodes and Insecticidal Mechanisms

Nematodes, which belong to the Neoaplectana and Heterorhabditis genuses, can be parasitic on insects and can kill their hosts. These nematodes have a special infective period when they can attack insects, but there is a difference between infective periods of both genuses with respect to their life cycle. When larvae are born in a period in which the vegetative condition of nematodes which belong to the Neoaplectana genus have deteriorated, these larvae will be in an infective condition in their third period (third instar). On the other hand, nematodes which belong to the Heterorhabditis genus ovoviviparously oviposit, hatch out of eggs and are in an infective condition in their second period (second instar). The life cycle of nematodes which belong to respective genuses is shown in Figure 1(a) and (b). When nematodes which belong to the Neoaplectana genus copulate with each other, they will oviposit. However, it is possible for nematodes which belong to the Heterorhabditis genus to carry out parthenogenesis, i.e., to oviposit without copulation. This is the largest difference between nematodes which belong to the Neoaplectana genus and those which belong to the Heterorhabditis genus.

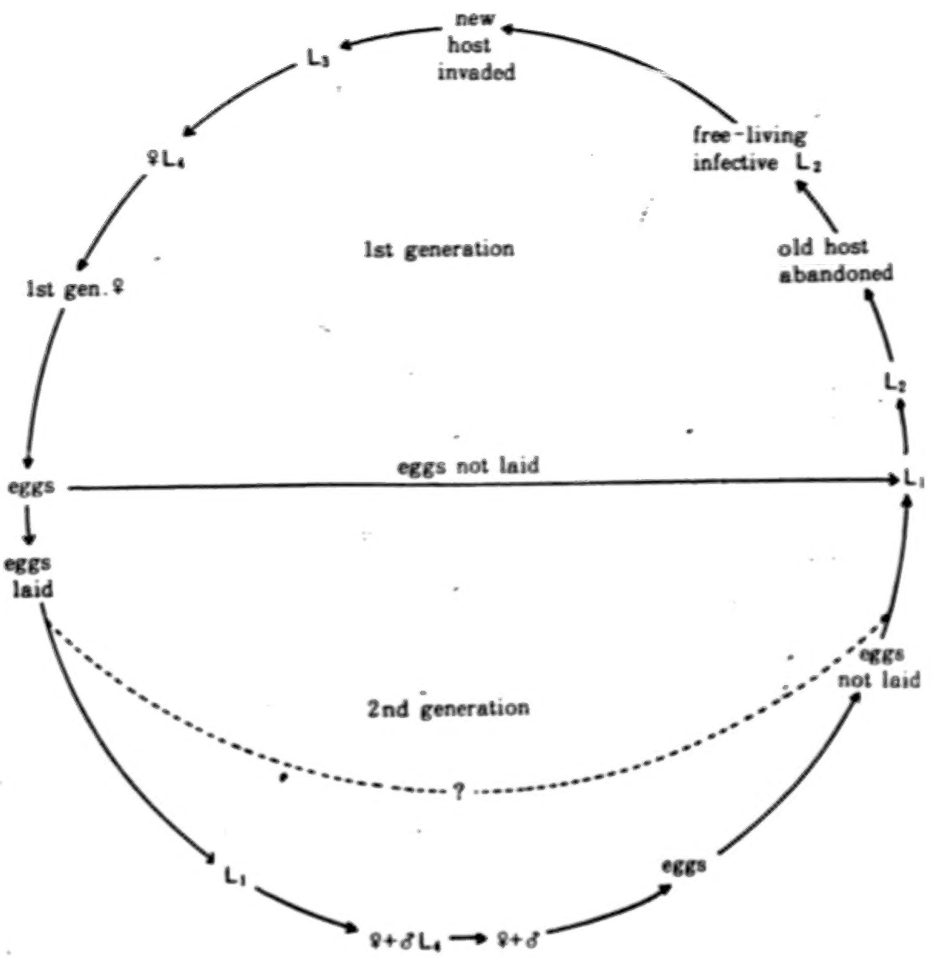

Figure 1(b). Life Cycle in Insect Host of H. heliotidis

Larvae which are in an infective condition have a cortical sheath. It can be considered that nematodes have obtained a cortical sheath during evolution with a view to protecting themselves from hostile environmental conditions until the nematodes meet hosts in the natural world.

As previously mentioned, larvae are in an infective condition. The approaching behavior of such larvae to hosts seems to be a response to chemical stimulation against some substance (for example, carbon dioxide, etc.) discharged from the hosts.[2,3] When nematodes adhere to hosts, they will invade from coeloms such as the mouth, spiracle, anus, etc., of these hosts.

After they molt, they further enter into the hemocoel (blood vessel) of the hosts. In the case of nematodes of the Heterorhabditis genus, it has been confirmed that they break the epidermal tissue of hosts and directly enter into the body of these hosts.[4] However, we consider that there are many cases in which they will enter from mouth into body of hosts.

Nematodes which have entered into the hemocoel of hosts will discharge symbiotic bacteria in the blood of these hosts. These symbiotic bacteria exist in the intestine of nematodes. Also, they belong to the Xenorhabdus genus. Hosts infected with nematodes will cause septicemia, and will die of it, because these bacteria propagate quickly. The nematodes which have infected these hosts will grow up while ingesting either bacteria or host tissues decomposed by the bacteria. After these nematodes repeat the propagation of two or three generations, they will become larvae which are in an infective condition and will go out of the body of dead insects. The period from infection to going-out depends on the size of host-insects and the number of nematodes which enter into the body of hosts. When Prodenia litura Fabricius sixth instar larvae are hosts, the period will be 7 to 10 days. However, there are still some unclear points in the problem of life cycle and entrance of nematodes, and research for clearing these points is being conducted continuously.

The Xenorhabdus is a symbiotic bacterium, and is classified into the X. nematophilus and X. luminescens. The X. nematophilus is symbiotic with nematodes which belong to the Neoaplectana genus. The X. luminescens is symbiotic with nematodes which belong to the Heterorhabditis genus. This symbiotic bacterium shows two morphological properties, i.e., primary and secondary forms. The insecticidal power of nematodes having the primary form in their bodies is stronger than that of nematodes having the secondary form in their bodies.[5-7] Symbiotic bacteria produce a substance which restrains other bacteria from maturing in the outside of the body of these symbiotic bacteria, and alkalize the culture medium. This alkalophily is closely related to pH in the body of insects. How is such alkalophily symbiotic in the body of nematodes? This is a problem which must be solved in the future.

3. Host Range of Entomogenous Nematodes

The wide parasitic range of nematodes can be cited as one of the features which show a strong possibility of nematodes being used as biological agricultural chemicals. As compared with other entomogenous nematodes, there are many test examples of the Neoaplectana carpocapsae. It has been found that the Neoaplectana carpocapsae. It has been found that the Neoaplectana carpocapsae show insecticidal power against about 250 kinds of larvae and imagoes ranging over 10 orders of Anthropoda.[8] There are many cases in which other nematodes are peculiarly parasitic on insects at a specific stage of these insects. However, no such peculiarity can be seen in the nematodes we have researched. Generally, there are a few cases in which insects die, because they will show a defensive reaction and nematodes cannot be propagated, even if the nematodes infect them. However, in the case of entomogenous nematodes, this phenomenon is exceptional. It seems that such phenomenon is caused by a quick propagation of symbiotic bacteria in blood rather than a defensive reaction (activation of phenoloxidase) of hosts against nematodes.

Experiments have demonstrated that entomogenous nematodes will kill many kinds of insects. These experiments were performed under conditions in which entomogenous nematodes are liable to infect insects. In reality, natural infection is hardly ever seen in the natural world because of environmental

factors, differences of habitats of insects, etc. There is an example in which nematodes synchronously vegetate against insects such as flies whose larvae live in soil in their life cycle, etc. Such examples have also been found in Japan. These nematodes are peculiar to insects, but are harmless to human beings and domestic animals.

4. Problems of Practical Use

It is possible that entomogenous nematodes can be used to prevent noxious insects from breeding and to exterminate these insects in the same way as general insecticides. This possibility has long been studied on the basis of high-insecticidal activity obtained from results of experiments. In reality, the United States and Europe have just started putting entomogenous nematodes to practical use for the above purposes on an intermediate scale. The reasons why such entomogenous nematodes have not been used widely and generally are as follows:

(1) In order to widely use entomogenous nematodes, it is necessary to cultivate a large number of them.

(2) When entomogenous nematodes are used under disadvantageous conditions, they will not show the high effect of preventing breeding and exterminating noxious insects, because the viability of these entomogenous nematodes is not so strong in environments hostile to their existence.

The first problem has been solved by establishing a method of artificially cultivating a large number of entomogenous nematodes. This method will be mentioned later on.

The second problem will be mentioned below, because it has almost been clarified.

Humidity is the largest environmental factor related to the existence of nematodes. Nematodes cannot exist over a long period of time, because moisture evaporates from their bodies in low-humidity conditions. Kamionek, et al.,[10] have demonstrated that 98 percent of the Neoaplectana carpocapsae DD-136 will die after 2½ hours in a temperature of 30°C with humidity at 20 percent. However, when the humidity is 85 percent, all of the Neoaplectana carpocapsae DD-136 survive, even after about 100 hours. Our experiments have shown that nematodes treated on leaf surfaces in the rainy season survive even after 3 days, but such nematodes die within 1 hour on a fine day. Considering the high-humidity dependence of nematodes, it seems to be better to Moore's report,[11] nematodes survived in soil for 24 days after they had been treated in a condition of infective larvae. When such nematodes are treated in soil, it seems possible for them to survive for a considerably long period of time, because they live in soil by nature. However, they may not be able to survive in soil for a long period of time, because there are small predatory animal groups in soil. Even in such a case, it seems possible to lengthen the survival period of nematodes by using other chemicals.

Nematodes are sensitive to temperatures, because they are living organisms. The optimum temperature is about 25°C. The activity of nematodes weakens under conditions in which temperatures are much lower or higher than this. When their activities are lowered, their infective power is lowered. As a result, their insecticidal activities are lowered.

These nematodes are affected by other conditions, such as sunlight, hydrogen ion concentration (pH), oxygen concentration, salt concentration, etc., and their infective power and insecticidal power to hosts is changed.[12]

5. Artificial Cultivation and Preservation of Nematodes

In order to widely use nematodes as biological agricultural chemicals to prevent noxious insects from breeding and to exterminate such insects, it is necessary to prepare a large number of infective larvae and to transport these to places where they will be used. Particularly, in order to commercialize such nematodes, it is necessary to consider reasonable prices, stable and simple transportation methods, appropriate methods of use, etc.

With regard to the method of manufacturing nematodes, Dutky, et al.,[13] established a method of cultivating large numbers of nematodes of using larvae of Calleria mellonella in 1964. A method of cultivating nematodes in vitro using dog biscuits was reported by House, et al.,[14] the following year. Recently, Bedding, et al., have reported that infective larvae can be obtained at a production efficiency of 38 million infective larvae per flask by using an inexpensive culture medium such as pig kidneys and cattle fat. In addition, it has been found that nematodes can be obtained at a faster propagation speed by simultaneously adding symbiotic bacteria and nematodes to this culture medium. If dog food on the market is used as a culture medium even at a laboratory level, infective larvae can be obtained at a production efficiency of 100,000 to 150,000 infective larvae per test tube. At present, further improvements have been made in research and development, and a technology has been established with a view to industrially produce infective larvae.

The simplest method of preserving nematodes is to cryogenically preserve them. They can be preserved for about 2 months without any decrease in their activities in conditions in which no nutrition is given to them. Although this method is very simple, it is an experimental method. Therefore, when nematodes are preserved industrially, other methods must be adopted. At present, research and development of an excellent method of preserving nematodes is being carried out. It seems that the adoption of this new method will simplify distribution, etc.

6. Safety of Nematodes

In order to widely use entomogenous nematodes, it is necessary to ensure the safety of mammals, fowl, fish, and other useful living organisms and not to exert a bad influence on the environment. In addition, in order to commercialize these nematodes, it is necessary to meet the standard for registering them.

Poinar, Gaugler, et al., have conducted experiments to investigate the influence of nematodes on mammals. They have orally or artificially administered nematodes to the abdominal cavity of rats and mice, but have not recognized either the occurrence of disease or death in these rats and mice. When nematodes were administered orally to these rats and mice, they were found dead discharged in feces. Also, when nematodes were put in the abdominal cavity of the rats and mice, it was observed that the nematodes were covered with celiac macrophage, causing death.[15,16]

As clearly mentioned in these reports, when nematodes are put into the body of a mammal, it seems that they do not survive and soon die.

Although no example of tests on human beings have been reported, I understand that a university professor who is prestigious in this field swallowed nematodes by mistake while conducting experiments. But even now, he is healthy and active.

With regard to experiments on fish, we administered 10,000 nematodes per milliliter to a water tank in which Oryzias latipes are kept, but there was no change in these Oryzias latipes.

Also, it has been observed that nematodes will not enter into the roots of plants.

7. Usage of Nematodes

The philosophy at the initial stage when the use of nematodes was first considered, was close to that in which nematodes are regarded as natural enemies and are acclimated in soil. Many experiments were conducted to acclimate nematodes in soil, prevent noxious insects from breeding, and exterminate these insects. Glaser, et al.,[17] conducted tests using the N. glaseri for the purpose of preventing Japanese beetles from breeding and exterminating them in the 1930's. This test can be cited as one example of using nematodes. Although a sufficient effect against Japanese beetles was obtained from the test, it resulted in failure, because it was impossible to use nematodes in soil over a long period of time.

Up to now, researchers of more than 10 countries have conducted research on entomogenous nematodes in order to put them to practical use as biological agricultural chemicals. However, there are few successful examples of such research. One reason is, as previously mentioned, that nematodes are regarded as natural enemies and are acclimated in the natural world. Another reason is that a wrong period for treating nematodes was determined. There are many cases where nematodes die before they contact noxious insects which could be exterminated and whose breeding could be prevented, because they cannot live long under disadvantageous environmental conditions. In addition, there are examples of tests which obtained limited success in preventing noxious insects from breeding and exterminating these insects.[18-20]

I will now introduce the experiment results and briefly describe philosophies for putting nematodes to practical use.

When suspension containing nematodes is scattered on noxious insects having a short life cycle, it is necessary to repeatedly scatter the suspension several times on these insects in the same way as general insecticides. The experiments have shown that a single scattering can almost annihilate the noxious larvae, but the remaining larvae start invading from peripheries, because the survival time of nematodes is short, and again the density of noxious insects is enhanced after a certain period of time. This phenomenon will occur even in the case of use of general insecticides. However, the length of time necessary for recovery depends on characteristics of respective insecticides. Generally, the effect cannot be asserted, because it depends on service conditions. However, conditions in which general insecticides can effectively exercise their power are disadvantageous for nematodes. Therefore, there are many cases in which the use of general insecticides under these conditions will not bring about satisfactory results. The most important matter is to use these general insecticides with consideration to their use under conditions in which the effect of nematodes can be enhanced.

In the case of noxious insects having a long life cycle, an appropriate treatment period can be selected. This is because of the stage and active conditions of noxious insects.

For example, when noxious insects such as Hyphantria cunea live at almost the same stage in a group. nematodes can be used effectively. This is because if only meteorological conditions are set so that nematodes can survive for a limited time, these nematodes will adhere to noxious insects without fail and will prove most effective.

Although the following treatment method is slightly different from the above method, it can be expected that nematodes will be very effective against noxious insects which live in the surface soil area. Particularly, when the surface soil area is overgrown with plants, the humidity at the surface will be increased from evening till morning. Therefore, when nematodes are treated at evening with the proper humidity, their insecticidal activity will increase.

The other effective method is to use the "insect exploratory behavior ability" of nematodes. However, in this case, the vitality and home range of nematodes will become a problem. Therefore, nematodes must be used at places and periods having conditions favorable for their survival. For example, high humidity, appropriate temperature, glare protection, etc., can be cited as such conditions. When noxious insects live in soil or inside plants such as inside leaves, trees, fruits, etc., nematodes can be scattered, poured, etc., on the soil or on the inside of these plants in the same way as in the above case. At present, the contents of the following two examples have been put to practical use on the basis of this method. I will now describe two examples.

The first is a case of bark beetles which eat almond trees and fruit trees in the United States. Nematodes are scattered on the trees, are eaten by noxious insects such as bark beetles to prevent them from breeding and to exterminate

those that are within the interiors of the trees. This case relies on stable conditions such as temperature, humidity, and glare protection on the inside of the trees. Judging from the effective power of nematodes in high humidity and under a clouded sky, it can be expected that these nematodes will exercise their power on noxious insects. But as compared with the former, the number of nematodes will be increased.

The second example is a successful case in Europe. This is a suggestive example. Black vine weevils are noxious insects. They are treated in soil of hothouses in which conditions can be artificially controlled.[21] Although black vine weevils have not yet been actually used in Japan, many researchers are conducting research on these noxious insects. There is a strong possibility that these insects will be put to practical use within several years.

In addition, these researchers are enthusiastically carrying out the development of entomogenous nematodes as more powerful bioagricultural chemicals while selecting dry-resistant nematodes and screening new kinds of nematodes with stronger insecticidal power.

8. Registration of Nematodes

The philosophy of the EPA (Environmental Protection Agency) in the United States on biological agricultural chemicals is as follows: Living organisms exist in the natural world, and are not subject to any artificial modification such as gene manipulation, etc. If the usefulness and safety of such living organisms can be demonstrated, these living organisms can be registered as bioagricultural chemicals and can be marketed while advocating their effect. Their usefulness is based on test data, and safety is based on acute and toxic data (literat also available) according to oral administration. Europe has the same philosophy. Such living organisms can be marketed, even if they are not registere , unless their effect is advocated.

There is a tendency for bioagricultural chemicals to be used increasingly throughout the world in proportion to the development of genetic engineering, natural physiological chemistry, and biological chemistry interpreted broadly. Also, bioagricultural chemicals are being reconsidered.

In the same way, it is anticipated that the number of bioagricultural chemicals registered in Japan will increase gradually.

We are conducting research on entomogenous nematodes. These exist in the natural world, and will not disturb the natural ecosystem. In addition, their safety is high.

We hope that entomogenous nematodes will be used as safe bioagricultural chemicals and will contribute to the prevention of breeding and extermination of noxious insects in Japanese agricultural and forestry industries. We want to further promote this research.

Finally, we are most grateful to Professor Nobuyoshi Ishibashi of the Department of Agriculture of Saga University and other researchers for their kind assistance in research. We also express our heartfelt gratitude to Biotechnology Australia Co., Ltd., for giving us an opportunity to do the research and for supplying entomogenous nematodes.

FOOTNOTES

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CSO: 4306/3617

U.S. NUCLEAR SUBMARINE TO CALL AT OKINAWA

OW250638 Tokyo KYODO in English 0632 GMT 25 Nov 86

[Text] Naha, 25 Nov (KYODO)--The U.S. nuclear-powered submarine San Francisco will make a port call at White Beach, Okinawa Prefecture, Wednesday, local prefectural government officials said Tuesday.

According to a report from the Foreign Ministry, the 6,000-ton submarine will call there for replenishment of supplies and leave for its 130 crew members, they said.

The San Francisco's Okinawa call marks the 20th such visit by a nuclear-powered submarine since the island was returned to Japanese administration in 1972.

The San Francisco is equipped with antisubmarine "Harpoon" missiles and can be fitted with Tomahawk cruise missiles capable of carrying nuclear warheads.

The submarine's departure date is not yet known, officials said.

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CSO: 4307/4

OKINAWANS PROTEST NUCLEAR SUBMARINE'S VISIT

OW260507 Tokyo KYODO in English 0355 GMT 26 Nov 86

[Text] Naha, 26 Nov (KYODO)--The U.S. nuclear-powered submarine San Francisco made a port call at White Beach, Okinawa, Wednesday to replenish supplies and give leave to its 130-member crew.

The Los Angeles class attack submarine headed by Cmdr J. C. Bathgate, is equipped with "Harpoon" anti-ship missiles and "Subroc" anti-submarine torpedo missiles. The San Francisco is also capable of carrying "Tomahawk" nuclear cruise missiles, according to "Jane's Fighting Ships" yearbook.

The 6,000-ton sub, calling at this U.S. naval base in Nakagami, eastern central Okinawa, is the 20th U.S. nuclear-powered naval vessel to visit Okinawa since the island was returned to Japan in 1972.

The last U.S. nuclear submarine to call was the Tunny in August this year.

It was not disclosed when San Francisco would depart the Okinawa port.

The Science and Technology Agency and Okinawa Prefecture officials said they will examine sea water surrounding the San Francisco, for possible radiation contamination.

A group of protesters held demonstrations at a hill near the White Beach U.S. naval base where the 110-meter long nuclear submarine San Francisco entered.

The protesters, mainly made up of some 50 local labor union members, yelled at U.S. Navy personnel, who were unloading the sub, that the "nuclear suspicious" sub should return home.

Hiroaki Fukuchi, local director of the Japan Socialist Party-affiliated antinuclear groups Japan Congress Against Atomic and Hydrogen Bombs, said, "The nuke sub's port call reconfirmed to us that Okinawa represents a point in the U.S. nuclear strategy. We will fight until U.S. bases disappear and the nuclear threat fades away from Okinawa."

The San Francisco entered White Beach before 11 am Tuesday [0200 GMT] accompanied by four vessels including a radiation detecting ship of Japan's Maritime Safety Agency.

The government has maintained that U.S. warships entering Japan do not carry nuclear weapons and prior notification by the U.S. side is required for any ships that carry such weapons.

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CSO: 4307/4

ENERGY COSTS IN YEAR 2000 ESTIMATED

Tokyo GENSHIRYOKU SANGYO SHIMBUN in Japanese 20 Jun 86 p 4

[Article: "Summary of Forecast of Energy Prices in Year 2000 by Japan Economic Research Institute"]

[Text] The Japan Economic Research Institute for Energy prepared a report on 12 June on the results of simulations concerning the supply and demand and cost of energy estimated for the year 2000. According to the report regarding oil prices, "the standard scenario estimates crude oil prices in the year 2000 to be about $30 per barrel." It reports that "if crude oil prices fall further in the future, they could possibly rebound." And, it points out "the necessity to work out measures more seriously than before to cope with the confusion that may arise." An outline of the report follows.

Crude Oil Prices Will Rise to $30 a Barrel--Will Rebound on Drastic Plunge

The simulations were carried out to forecast the supply-demand and price situations of energy, particularly oil, assuming the average market price of crude oil drops from $26.50 per barrel in 1985 to $25, $20, $15, and $10, in 1986.

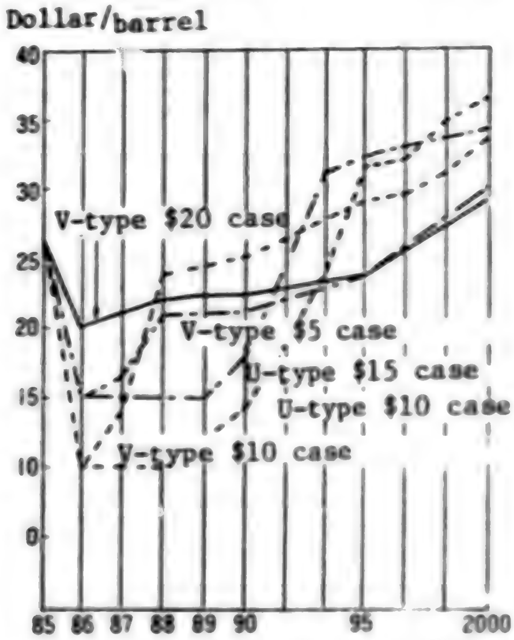
According to a scenario of crude oil prices based on the results of simulations, crude oil prices will continue to repeat wild fluctuations centering around the level of $15-$18 for the period of 2-3 years to come. When this chaotic period is over, it will remain at a little over the $20 level from the end of the 1980's to the early 1990's, later increasing in the mid-1990's, reaching about $24 in 1995 and about $30 in the year 2000.

The simulation was carried out according to a "V-type scenario" where presently declining crude oil prices turn sharply upward in 2-3 years, and the "U-type scenario" where they remain at the low level of $10 and $15 throughout the 1980's. Under the V-type scenario the sharper the drop the more the price rebounds drastically.

The reason is that if crude oil prices drop below the level of $15, it will hasten the suspension of oil prospecting, the reduction of investment for oil development, and the closing of oil fields. On the other hand, however, the demand for crude oil will grow while the supply capability of substitute energy declines because dependence on OPEC's oil will suddenly increase.

This trend will especially occur in the United States and result in a sharp increase in oil imports.

Under the U-type scenario this tendency will reach its peak in the early 1990's and crude oil prices will soar substantially. This is the reason why the U-type scenario has not been adopted as a standard scenario.



Scenario of Crude Oil Price

(Actual price of 1986 average market price)

Table of Crude Oil Price Scenario
(Actual price average market price)

	V-type scenario			U-type scenario		Standard scenario
	$20	$15	$10	$15	$10	Standard
1985	26.50	26.50	26.50	26.50	26.50	26.50
86	20.00	15.00	10.00	15.00	10.00	17.00
87	21.20	16.50	14.00	15.00	10.00	17.00
88	22.05	21.00	24.00	15.00	10.00	18.00
89	22.49	21.00	24.60	15.00	12.00	20.00
90	22.49	21.21	25.22	18.00	14.40	21.00
95	23.87	23.64	29.09	32.36	31.57	24.00
2000	29.31	30.18	33.72	34.35	36.60	30.00

To make clear the effects of a sharp decrease in crude oil prices and the problematic points, a study was made by fixing actual crude oil prices for 10 years up to 1995 at $25, $20, $15, and $10 and as a result it revealed

Forecast for Supply and Demand of Prim.ry Energy
(Actual set prices for 10 years)

At $25/barrel (1 million barrels/day)

	1985	1990	1995
Oil	45.6(46.9)	48.2(44.7)	51.0(43.1)
Coal	20.8(21.4)	23.4(21.7)	27.5(23.3)
Natural gas	17.4(17.9)	18.9(17.5)	20.5(17.3)
Atomic power	5.6(5.8)	9.0(8.4)	10.6(9.0)
Hydraulic power, etc.	7.9(8.1)	8.2(7.6)	8.7(7.4)
Total	97.3(100.0)	107.7(100.0)	118.3(100.0)

At $20/barrel

	1985	1990	1995
Oil	45.6(46.9)	49.2(45.0)	53.2(43.7)
Coal	20.8(21.4)	23.7(21.7)	28.2(23.2)
Natural gas	17.4(17.9)	18.9(17.3)	20.5(16.8)
Atomic power	5.6(5.8)	9.1(8.4)	10.9(9.0)
Hydraulic power, etc.	7.9(8.1)	8.3(7.6)	9.0(7.4)
Total	97.3(100.0)	109.3(100.0)	121.8(100.0)

At $15/barrel

	1985	1990	1995
Oil	45.6(46.9)	51.6(46.4)	57.7(45.7)
Coal	20.8(21.4)	23.9(21.5)	28.7(22.7)
Natural gas	17.4(17.9)	18.1(16.3)	19.7(15.6)
Atomic power	5.6(5.8)	9.3(8.4)	11.1(8.8)
Hydraulic power, etc.	7.9(8.1)	8.4(7.5)	9.1(7.2)
Total	97.3(100.0)	111.3(100.0)	126.3(100.0)

World's total exclusive of communist bloc

that in the case of $15 the amount of crude oil to be procured from OPEC would reach 27.3 million barrels a day in 1990 and 36.4 million barrels a day in 1995. In the case of $10 it would reach 33.2 million barrels a day in 1990 and 46.7 million barrels a day in 1995.

This means that the amount exceeds OPEC's estimated production capacity for each year; i.e., in the case of $15 by 5.9 million barrels a day for 1995 and in the case of $10, 2.7 million barrels a day for 1990 and 16.2 million barrels a day for 1995.

The results of these fixed cases indicate that the present sharp decline in crude oil price is economically excessive and that if the price continues at the levels of $15 and $10, there is a strong likelihood that the actual price will increase substantially before 1990. In the case of $20 the actual price will increase in the early 1990's and in the case of $25 it will increase after the mid-1990's nearly the same as that previously anticipated.

The effects of decline in crude oil price on demand are insignificant from a short-range outlook, but significant from a medium- and long-range outlook. The more crude oil prices fall sharply, the more the growth rate of the world economy will rise and energy demand increase.

In particular, if the price is pegged over a long period at a level much lower than $20, the recovery of oil demand will gain in speed, including the reconversion of substitute energy for oil. While with respect to supply, if crude oil prices drop below $20, a decline will show in supply capability of non-OPEC crude oil and some substitute energy. Especially, if crude oil prices drop below $15, the decreasing amount of supply would sharply increase due to the declining capability [as published].

With respect to the decrease in the supply capability of substitute energy, if crude oil prices fall below $20, the economical efficiency of new LNG development projects will greatly decline and if the price is at around the $15 level, the amount of coal production and its exports will decrease to a considerable extent. In other words, the economical efficiency of the estimated future new projects of coal development and export will worsen. The production of natural gas will also decrease along with decreasing crude oil production. Even atomic power generation at the $10-$15 level, will find its competitive power weakening against heavy fuel oil and coal.

As a result, the dependence on OPEC for its crude oil will inevitably increase compared with the general outlook except for those of the $25 case.

Particularly, in the case set at $10-$15 the amount of required crude oil production of the consolidated balance of OPEC, including the declining substitute energy supply capacity, is calculated to reach an unrealistic scale from a medium- and long-range outlook.

Therefore, crude oil prices actually will rebound more drastically at an early stage from a medium-range viewpoint the greater it declines, as the mechanism in adjusting supply and demand works.

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CSO: 4306/2626

ENERGY

IEA AGREES ON STACK GAS TREATMENT TECHNOLOGY

OW121131 Tokyo KYODO in English 0911 GMT 12 Nov 86

[Text] Tokyo, 12 Nov (KYODO)--The International Energy Agency (IEA) Wednesday agreed that plans for cooperation in developing advanced technology and improving existing technology for treatment of flue gases should be drawn up within the next half-year.

The agreement came at the end of a 2-day IEA workshop on flue gas treatment in Tokyo, a Ministry of International Trade and Industry official said. The seminar was attended by representatives of the nine member states of IEA.

It was also agreed that various countries would draw up specific plans on the basic research within 6 months.

The United States would be responsible for the plan on the development of advanced technology and improvement of current technology for desulfurization of coal stack gas, Japan for denitrification, and Australia for dust collection.

Since the second international oil crunch of 1979, coal-fired power generation has become active again among various countries, particularly with Sweden and West Germany, which are reviewing the atomic power generation plans, the official said. IEA agreed earlier on the promotion of international cooperation in coal utilization.

The nine IEA members are Australia, Denmark, West Germany, Italy, Japan, the Netherlands, Sweden, Britain, and the United States. A representative of the EC attended the workshop as an observer.

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CSO: 4307/4

MITI CONSIDERS DRASTIC CUT IN COAL PRODUCTION

OW281059 Tokyo KYODO in English 0651 GMT 28 Nov 86

[Text] Tokyo, 28 Nov (KYODO)--A government panel Friday submitted a final report to International Trade and Industry Minister Hajime Tamura urging a drastic cut in domestic coal production, government officials said.

The 14-page report, which determines the future of the domestic coal mining industry in the next 5-year period, beginning next April, was prepared by the Coal Mining Council, chaired by Yoshihiro Inayama, honorary president of the Japan Iron and Steel Federation.

It said domestic output of metallurgical coal--used mainly in steelmaking--will be phased out in 1990, the final fiscal year of the plan, and steam coal will gradually be reduced to around 10 million tons annually in fiscal 1991.

The drastic cutback of domestic coal production will make the ratio of imported coal rise to more than 90 percent of Japan's overall coal consumption, projected at 108 million tons in fiscal 1990, from about 85 percent in fiscal 1985, ended last March, the officials said.

Japan consumed a total of 109.38 million tons in fiscal 1985, in which 92.60 million tons were imported from overseas. Japan's domestic coal output continued to plunge after peaking at 55.41 million tons in 1961.

The so-called Maekawa report, conceived by Prime Minister Yasuhiro Nakasone's advisers led by former Bank of Japan Governor Haruo Maekawa, earlier requested the government to scale down the domestic coal mining industry, which has already lost international competitiveness, and to increase imports of foreign coal.

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CSO: 4307/4

ENERGY

JAPAN, PRC TO DISCUSS IMPORTS OF CHINESE COAL

OW211337 Tokyo KYODO in English 1221 GMT 21 Nov 86

[Text] Nagasaki, 21 Nov (KYODO)--Japan's major coal users will hold a meeting with China in Nagasaki next Tuesday and Wednesday on the import of Chinese coal.

An 11-member Chinese delegation, led by Wei Guofu, first deputy manager of the China National Coal Import and Export Corp., will attend the meeting, the sixth in an annual series held alternately in Japan and China.

The Japanese side will consist of representatives of major users, such as steelmakers, electric power firms, and cement makers.

Nagasaki has been chosen as the site of this year's meeting as the Matsushima power station in Nagasaki Prefecture is fueled by coal imported from China's Shuzhou, where last year's meeting took place.

Japan agreed to import 4 million tons of Chinese coal annually over 5 years under a bilateral long-term trade agreement concluded in January this year.

At the meeting, Japanese users will raise the issue of the quality of Chinese coal, while the Chinese side will take up the problem of improving coal transport and report on the ongoing construction of seven coal mines in Shandong Province and elsewhere, which is financed by a Japanese loan.

/9599
CSO: 4307/4

MARINE TECHNOLOGY

DEVELOPMENT OF COBALT-RICH MANGANESE CRUSTS REPORTED

Tokyo KAIYO KAIHATSU in Japanese Jul 86 pp 22-27

[Article by the Ocean Development Office, Agency of Natural Resources and Energy, MITI: "Cobalt-Rich Manganese Crusts Are Expected To Contribute Greatly to Japan's Medium and Long-Term Secure, Stable Supply of Rare Metal Resources"]

[Text] 1. Introduction

A cobalt-rich manganese crust is rapidly gaining worldwide attention, particularly in Europe and the United States, as the third deep-sea mineral resource, after a manganese nodule and a submarine hydrothermal deposit. The cobalt-rich manganese crust is a promising marine-ocean rare metal resource which includes a number of rare metals such as cobalt and nickle. With regard to cobalt, this crust has a grade about 10 times that of its land counterpart; it is expected to be available in great quantities due to its wide occurrence in the Pacific Ocean region.

Four times since March of this year MITI has held a "Workshop on Probing Cobalt-Rich Manganese Crusts" as a symposium by the director-general of the Agency of Natural Resources and Energy to study basic ways to probe, develop, and utilize cobalt-rich manganese crusts; they issued an interim report on 19 June. This article will introduce to readers the outline and describe MITI's future plan to tackle new marine-ocean rare metal resources.

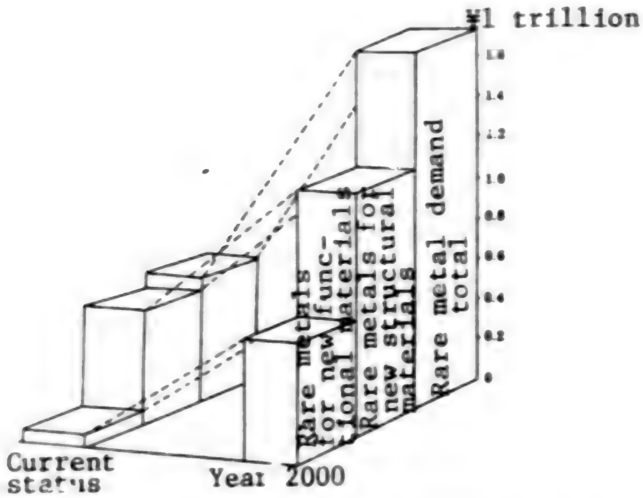
2. Outline of the Interim Report

2.1 Significance of Development of Cobalt-Rich Manganese Crusts

(1) Importance of Rare Metals

a. In the rapid progress of informationization in economic, social activities, and progress of technical innovation in new frontier sectors of industries such as space, needs for new materials are on the increase. With regard to rare metals such as nickle and cobalt as raw materials for these new materials, their market scale in the year 2000 is expected to expand to ¥1.7 trillion, about three times the current one. "New structural materials" (such as carbide tools and stainless steel) with cobalt and nickle added to traditional iron-based structural materials in particular have come to be

used widely. In the future their utilization as "new functional materials" (such as noncrystalline magnetic materials and shape memory alloys) aimed at functions of various rare metals is expected to increase rapidly.



	Current market scale A (¥10 billion)	Market scale in year 2000 B (¥10 billion)	B/A
For new functional materials	3.5	53.6	15.3
For new structural materials	55.1	116.1	2.1
Total	58.6	169.7	2.9

Based on sources compiled by the Mining Industry Council

Figure 1. Perspective of Rare Metal Market Scale in Japan

b. On the other hand, since rare metals are produced in a few specified nations and their supply is not stable, their supply measures have been furthered in cooperation between the administration and the private sector: a rare metal stockpile system was started in 1984 to meet short-term obstacles and the Rare Metal Overall Special Subcommittee of the Mine Subcommittee of the Mining Industry Council made a report entitled "On Rare Metal Overall Measures" in December 1985. However, looking at the current situation reveals that medium and long-term stable supply measures, for example, such as probe and development activities for cobalt deposits, are still insufficient.

(2) Importance of Cobalt-Rich Manganese Crusts

a. In this context, a cobalt-rich manganese crust has been rapidly gaining attention recently in Europe and the United States as the "third deep-sea mineral resource" following a manganese nodule and submarine hydrothermal deposit. The crust is considered to exist on bed rocks of comparatively old submarine slopes or flat tops in a depth of 800 to 2,400 m.

b. Cobalt-rich manganese crust features:

1) Contains in addition to cobalt a number of rare metals such as nickle and manganese, platinum, titanium, vanadium, lanthanum, and selenium.

2) Contains cobalt with a grade 10 times that of its land counterpart. It is considered to be a rare metal resource with extremely good quality as shown in its grade about 10 times as high as that of Kappa belt-type deposit, a representative land cobalt resource.

3) Quantitative expectations due to its widespread occurrence in the same way as manganese nodules: it is reported that surveys by the United States found that within the U.S.'s Pacific exclusive economic zone alone, there exists enough cobalt for Japan's needs for 20,000 years in cobalt-rich manganese crusts (see Table 1). Thus, a cobalt-rich manganese crust is an attractive resource and its development is expected to contribute greatly to medium and long-term secured stable supply of rare metals.

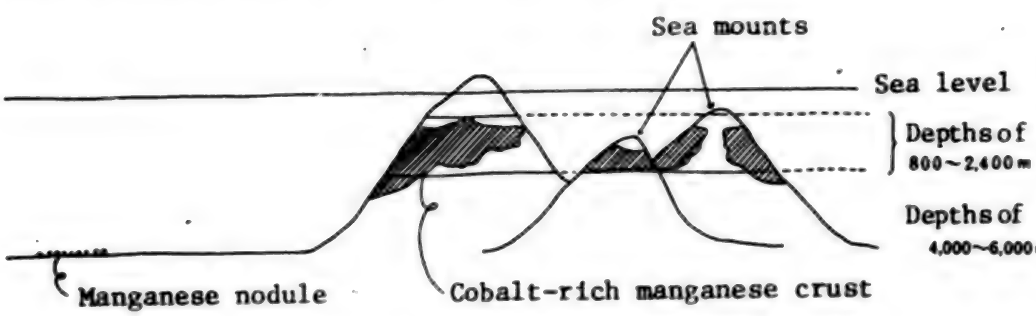


Figure 2. Depths of Cobalt-Rich Manganese Crusts

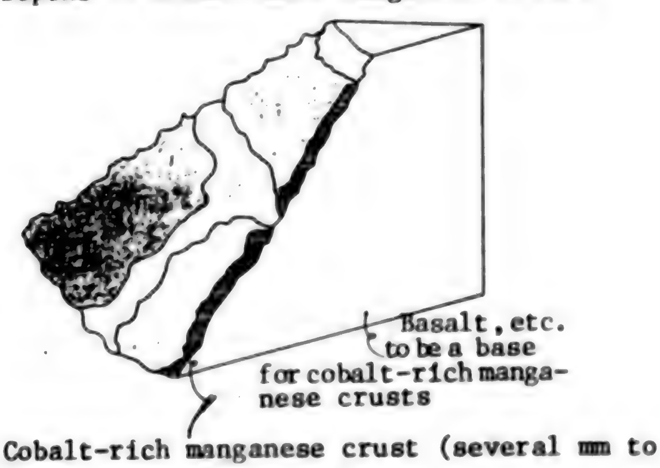


Figure 3. Cross-Section of Existing Cobalt-Rich Manganese Crust

Table 1. Reserves of Cobalt-Rich Manganese Crust

Reserves of crust 4.0×10^9t (A)	Japan's cobalt consumption (B)	(A)/(B)
Cobalt (0.88 percent) 3.9×10^7t	1.8×10^3t	22,000 years
Nickle (0.48 percent) 2.1×10^7t	1.3×10^5t	160 years
Manganese (24 percent) 1.1×10^9t	3.5×10^6t	310 years
Platinum (0.5 ppm) 0.2×10^4t	40 t	50 years

(Note) A is reserves in the U.S.'s exclusive economic zone in the Pacific Ocean except for Hawaii.

Source: Clark et al., (1985) Cobalt-Rich Manganese Crust Potential, Exclusive Economic Zone: U.S. Trust and Affiliated Territories in the Pacific

B is an estimate by the Agency of Natural Resources in FY 1984.

(3) International Trend in the Development of Cobalt-Rich Manganese Crusts

Full-scale research having been carried out since 1981 with cooperation of West Germany and the United States found that cobalt-rich manganese crusts are distributed semicontinuously in a considerably wide range on hard bases and that they are likely to be an economical mineral resource. The two nations have since then continued their probing activities energetically, while France recently started its research. In addition, the Soviets and India also reportedly initiated their probing activities; thus, nations advanced in ocean technology have started vying with one another in probing cobalt-rich manganese crusts (see Table 2). Meanwhile, it is only recently that natural research organizations and some private enterprises initiated their basic research in Japan.

(4) Technological System Related to the Development of Cobalt-Rich Manganese Crusts

a. As for technologies related to the development of cobalt-rich manganese crusts, it is possible to use technologies to develop manganese nodules and submarine hydrothermal deposits. Concerning sampling technology of probe technologies and working technology of exploitation technologies, it is considered that applied studies and new research and development will be necessary.

Table 2. Current Status of Cobalt-Rich Manganese Crust Research in Western Nations

Period	Probing nation and organization	Sea area	Research ship	Research content and result
15 June- 15 July 1981	(West Germany) Univ. Clausthal German National Science Foundation (United States) U.S.G.S.	Pacific central mountains Line Islands	Sonne	o Clarification of how cobalt crusts are produced and their production environment. o Acoustic probe: SBP, measurement o Submarine orbservation: submarine photography o Recovery: dredge, free-fall grab, gravity corer, and sea-water recovery o Onboard analysis of samples (fluorescence X-ray analysis of Mn, Fe, Co, Cu, Ni)
29 October- 29 November 1983	(United States) U.S.G.S.	Pacific central mountains Line Islands	S.P. Lee	o Research into how cobalt crusts are produced, submarine geology and their creation environment o Acoustic probe: 3.5 KHz, 12 KHz, and air gun o Submarine observation: CDC, video camera o Recovery: dredge, free-fall corer, gravity corer and CTD (equipped with an O_2 sensor)
28 August- 15 September 1984	(United States) U.S.G.S.	Marshall Islands	S.P. Lee	o Research into distribution and structure of cobalt crusts in Marshall Islands. o Acoustic probe: 3.5 KHz, 12 KHz, and air gun o Recovery: dredge, box corer
June 1984	(West Germany) Univ. Clausthal German National Science Foundation	Hawaiian Islands	Sonne	o Distribution of cobalt crusts in waters south of Hawaii, Pacific central mountains, and Line Islands o Acoustic probe: depth measurement, SBP o Submarine observation: submarine photography, video camera o Recovery: dredge, crab bucket
12 March- 9 September 1984	(United States) MMS [expansion not provided] Hawaii Univ.	Hawaiian Islands	Kana Keoki	o Research to prepare EIS (Environmental Impact Statement) by MMS, research activities charged by Hawaii Univ. o Probe of gravity, magnetism and earthquakes and submarine research by Sea Mark II
1986	(France) IFREMER [expansion not provided]	Tuamotu Archipelago	Jean Charcot	o Research by sea beam using an SAR (deep-sea towed side scan sonar) and EPULARD (6,000-m-class unmanned survey machine) o Research was carried out in two voyages in 1986, two more planned in 1988

(5) Desired Japanese Response

a. Considering Japan's 10-20 year delay compared with Western advanced nations in initiation of its research activities for manganese nodules and submarine hydrothermal deposits, it is necessary to initiate research into cobalt-rich manganese crusts as soon as possible to achieve results; it is strongly hoped that a full-scale research activity will be initiated in 1987.

b. With regard to their developmental system, it is anticipated that they will finally be developed by private businesses; however, it is necessary for the government to take the lead in basic survey and technological development such as exploitation and refining.

2.2 Desired Way of Probing Cobalt-Rich Manganese Crusts

(1) A Choice of Waters To Be Probed

a. In view of the current theories on creation and existence of cobalt-rich manganese crusts, data demonstrated so far and Japan's geographical conditions, the most promising waters to be proved are considered to be central Pacific and western Pacific as shown in Figure 6.

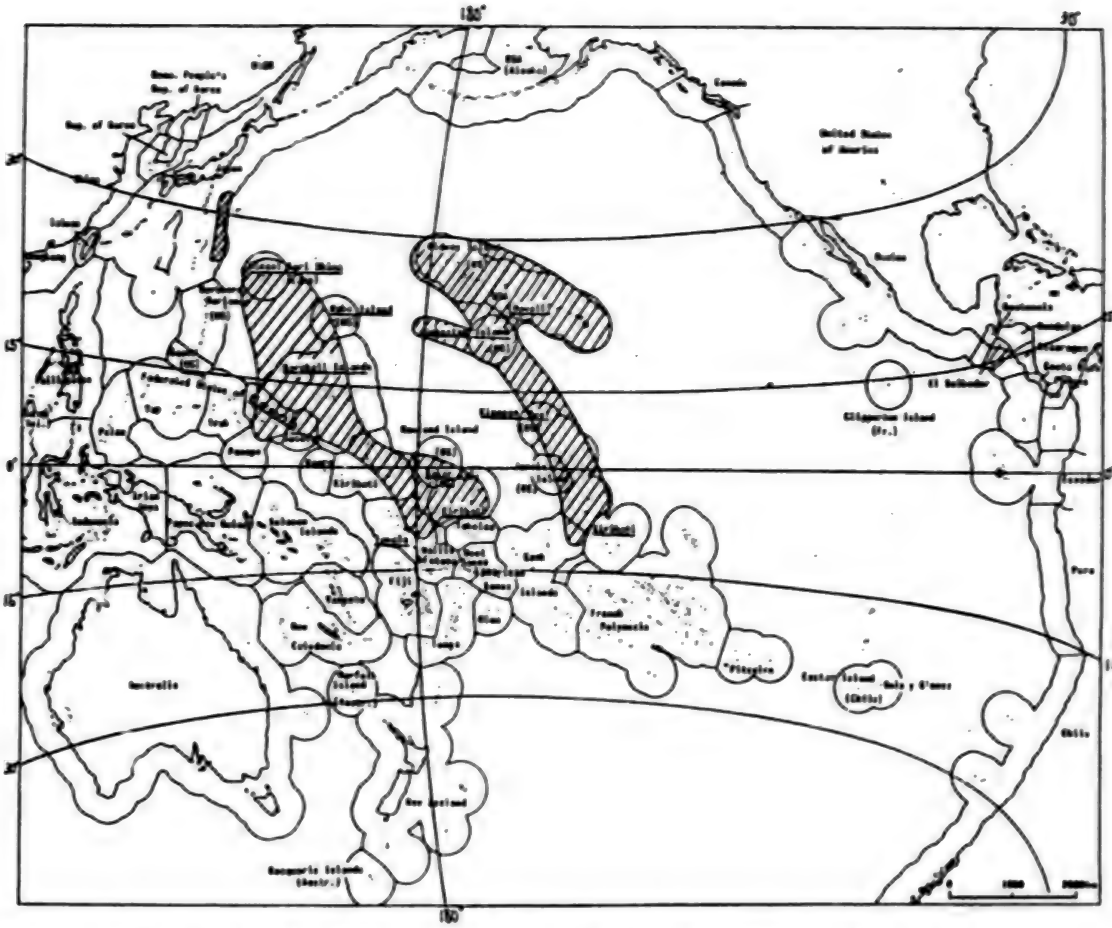
b. Incidentally, Marshall Islands, Republic of Kiribati and Tuvalu have made a strong request to Japan for survey of cobalt-rich manganese crusts in their peripheral waters under an ODA (official development assistance) project.

(2) Probing Method

In conducting probing activities, it is important to plan to carry out a probe in stages from finding a sea mount to finally discovering a cobalt-rich manganese crust and grasping the outline of its metallogenetic scale. In view of actual conditions of existence of cobalt-rich manganese crusts, a four stage probing method from prior survey to tertiary general survey is considered appropriate (see Table 3).

(3) Probe Period

A general standard for a period to conduct a probe of cobalt-rich manganese crusts may be about 10 years as is the case with manganese nodules and submarine hydrothermal deposits. However, considering the feasibility of their commercialization in the comparatively near future, it is desirable, not necessarily to stick to the abovementioned standard, but to work out an entire project and shape a vision on a case-by-case basis according to progress in probe technologies and the status of surveys in Western nations.



Source: Each nation's 200 mile zone is based on 200-Meilen-Zonen im Pazifischen Ozean (Entwurf N.J. Buchhelz, Kartnnranhic R. Nahn. O. Ruhlenann). [as published]

Figure 6. Promising Waters in the Pacific Ocean of Cobalt-Rich Manganese Crusts From the Geological and Metallogenetic Standpoint

Table.

Western Pacific	Central Pacific
Izu Islands, Ogasawara Islands, Minami Torishima Island, Wake Island, Marshall Islands, Micronesian Islands, Gilbert Islands, Tuvalu Islands	Hawaiian Islands Line Islands

Note: Part of the Gilbert Islands and Line Islands belong to the Republic of Kiribati.

2.3 Development and Utilization of Cobalt-Rich Manganese Crusts

(1) Exploitation of Cobalt-Rich Manganese Crusts

a. With a cobalt-rich manganese crust, as a manganese nodule, technological development for exploitation becomes an important factor having influence upon developmental feasibility. The current exploitation system is largely divided into a digging part to dig deposits on the seabottom and a deposit lift part to lift them out of the sea (see Figure 7).

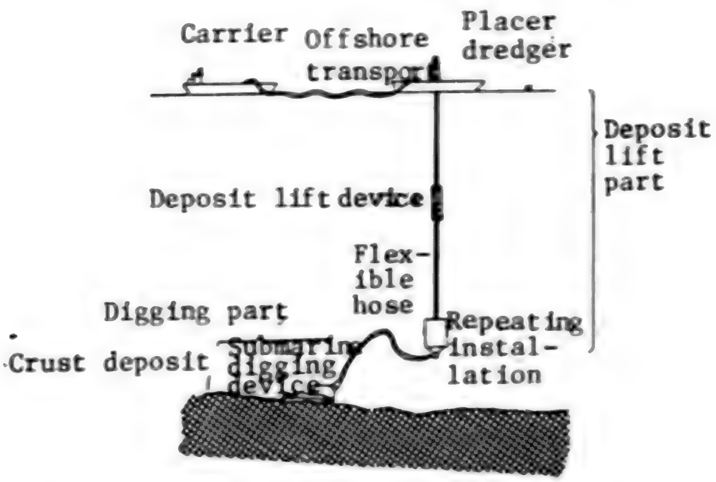


Figure 7. Exploitation System for Cobalt-Rich Manganese Crusts

b. Parallel to the immediate start of a probe, initiation of the development of exploitation technologies is desirable. In this case, with regard to the deposit lift part, it is thought that the results of the manganese nodule exploitation system in the main project can be utilized; while as to the digging part, it is necessary to separately develop technology of efficiently recovering crust part alone. To this end, it is necessary to expand and reinforce survey and development by the Deep-Sea Mineral Resources Development Association and the National Research Institute for Pollution and Resources.

(2) Utilization of Cobalt-Rich Manganese Crusts

With regard to refining technology for cobalt-rich manganese crusts, the point is, as with manganese nodules, how to establish an economical refining method. The refining technology for manganese nodules currently under development can be referred to, while it is considered that it is also necessary to develop concentration technology as prior processing to refining. It is also needed to step up efforts to expand R&D together with basic research started in the current fiscal year by the National Research Institute for Pollution and Resources.

Table 3.

Probe stage	Main probe aim	Main probe equipment	Remark
Prior survey	Finding sea mounts	Topography research: PDR, NBS, sea beam Bottom sediment structure: PDE, SBP, air gun Positioning: GPS, Loran-C, NNSS	About 5-sea mile interval
Primary general survey	Grasp of features of topography and geological structure of sea mounts Confirming an outline of existence conditions of CRC by sea mount Grasp of CRC creation environmental factors	Geography, geological structure: PDR, SBP, NBS Sampling: dredge bucket Submarine observation: CDC Research into sea water, etc.: bottom deposit sampler, CTD, water sampler, flow direction/velocity meter	About 25-sea mile interval
Secondary general survey	Grasp of microtopography of sea mounts Grasp of continuous existence conditions of CRC	Topography research: SSS Submarine observation: CDC Sampling: finder-equipped grab	About 1-sea mile interval
Tertiary general survey	Confirmation of the thickness of deposits Grasp of their general scales	Sampling: submarine drilling Submarine observation: CDC, submergible vessel	

Note 1: CRC is short for cobalt-rich manganese crust.
Note 2: Intervals shown in the remark column are siding intervals in topography research

Cobalt-rich manganese crusts contain rare metals that at the moment are impossible to obtain for economic reasons. However, as can be understood from the example of gallium contained in black ore deposits where it drew attention rapidly as a semiconductor material along with growth of information-related industries with a result that its refining method was developed later, cobalt-rich manganese crusts containing a number of rare metals are very likely to find a wider range of new applications, posing a problem of developing a refining method responding to this.

3. Future Approaches

MITI, on its part, in response to the result summarized in the interim report by the workshop on probe of cobalt-rich manganese crusts, intends to make efforts to materialize the proposal as much as possible in the future.

As the current interim report tells, a cobalt-rich manganese crust contains a number of rare metals and high-grade cobalt and poses few problems of supply compared with land cobalt resources, so that it is expected to contribute greatly to medium and long-term secured stable supply of rare metal resources in Japan. Also, there are still unknown aspects from the geological and metallogenetic standpoint; and it is likely to find new applications if good research results are achieved in the future. While research in Western nations are already achieving good results, Japan has no technological barriers to successful research since it has a high level of technologies for probing deep-sea mineral resources.

In starting a probe of cobalt-rich manganese crusts in the future, MITI intends to exchange information as required with the United States, and other countries, through detaching joint missions of the government and the private sector. Or by issuing invitations to researchers from the United States, it can formulate a "basic probe project" on the basis of the current report targeting November to December this year and initiate Japan's first full-scale probe project in FY 1987.

20,117/9365
CSO: 4306/589

MAJOR MARINE TECHNOLOGY INSTRUMENTS BUILT

Tokyo KAIYO KAIHATSU in Japanese Jul 86 pp 38-41

[Article by the Technical Division, Maritime Safety Agency, Ministry of Transport]

[Text] The Technical Division, Marine Safety Agency, Ministry of Transport, periodically compiles "The Major Marine Equipment Construction in Japan," which has been used by all concerned as data for actual results in marine equipment construction. A summary of the December 1985 revision is presented here.

1. Introduction

Under cooperation of individual shipbuilders and ocean development specialized companies, the bureau every year conducts performance surveys on main marine equipment built in Japan by means of a questionnaire. The latest survey was conducted on marine equipment completed between 1 April 1984 and 31 March 1985, targeted at 11 companies, with a result that the "Main Marine Equipment Built in Japan" has been summarized.

Table 1 is a numerical list by model and completion year of the marine equipment built over the past 15 years from FY 1970 to 1984. Further, in this article are summarized building performance by model for the past 15 years of individual marine equipment builders and main data, functions, and owners of marine equipment built for the same period. These survey results are utilized as important administrative sources, while it is believed that they will greatly serve those engaged in the development of marine equipment as basic sources to know the trend of ocean development.

2. Marine Equipment Sales by Main Sectors

Japan's ocean development related sales increased rapidly as shown in Figure 1 from FY 1979 (¥688.3 billion) on, accounting for ¥1.185 trillion in FY 1983, up 72 percent over FY 1974. The marine equipment sales-to-marine development related total sales ratio increased from 22 to 45 percent in 4 years from FY 1978 to 1982, decreasing to 35 percent in FY 1983. This is because of a decrease in sales of petroleum development related equipment as was the case with petroleum drilling rigs in FY 1983 where the number of building sharply decreased to five: of the marine equipment sales, those of

Table 1. List of Marine Equipment Built in Japan

Section	1 海洋調査				2 海洋工事								3					4 資源開発								5 海域利用							6			7	
Fiscal year of completion	1	2	3	4	1	2	3	4	5	6	7	8	1	2	3	4	5	1 石油掘削リグ (1) JU型	1 (2) SS型	1 (3)	1 (4)	2	3 (1)	3 (2)	4	1	2	3	4	5	6	7	1	2	3	1	Total
1970	11				2	1			2	1		1			2		1	2	1	2			5						5		3		1			1	41
1971	6				3	1			1			3	1	3	2				1	2			2		3				2	1	1		4	1			37
1972	10					4	2		1						1					1			4		2			2	5	1	1		6	1	3	1	45
1973	7				3	3	3		4	1	1	1		1	3				1				4		6				1	1			9		1	2	52
1974	11				1	2					2			3	1	1			1				4	1	12	1			2		3	1	9	5	2		62
1975	9			1	4						5	1		1	1	1		2	1	1			1		2				1		1		6	5	9	4	55
1976	10				2				3		12	2				1		4	5	4			13		9		1		1				3	7			77
1977	7	1			2		3	2		1	9	1						1	1	1				5	4	4	6		8				2	4	2		64
1978	18				2	1	1		1	3	7	1	1	3	1	1		2					8	3	9			2	3				2	6	3	2	80
1979	15				6	1	2			1	5	2			1			4					1	23	13		2		5	3			4	33	5	9	135
1980	19				1	1		2			2				1			13					4	5	2	1	1	1	4	2	2		2	2	1		67
1981	6								1		4	1	1	3		1		15					2	13	18	2	3		5	1	1		3		1		81
1982	8						2				3	5						9	12		1			17	24	2	1		5	1	1		1	1	2		96
1983	8				1		1				6	6		2				3	2				1	14	17				8	1	1			1	2		74
1984	7	3		1	1	2	4		1		2	4	1		1	1		3	1	1	1		2	9	15				8	4			3				75
Total	152	4		2	28	16	18	4	14	7	58	28	4	16	14	6	1	58	25	12	2		51	90	136	10	14	5	63	15	14	1	56	66	31	19	1040

Key:

1. Marine research
   1. Marine research vessel
   2.
   3. Marine observation buoy
   4. Miscellaneous
2. Marine construction
   1. Laying vessel
   2. Crane vessel
   3. Ground improving vessel
   4. Rock cutter
   5. JU bench vessel
   6. SS bench vessel
   7. Special carrier
   8. Miscellaneous
3. Submarine Research and Operation
   1. Submarine research vessel
   2. Submarine operation vessel
   3. Submarine operation equipment
   4. Support vessel
   5. Submarine operation facility
4. Resources Development
   1. Petroleum drilling rig
      (1) JU type
      (2) SS type
      (3) Vessel type
      (4) Miscellaneous
   2. Resources development vessel
   3. (1) Jacket
      (2) Module
5. Other auxiliary vessels
   1. Offshore living facility
   2. Offshore plant
   3. Offshore storage facility
   4. Port facility
   5. Fisheries facility
   6. Sightseeing facility
   7. Miscellaneous
6. Environmental protection
   1. Surface cleaning vessel
   2. Oil recovery vessel
   3. Environmental protection vessel
7. Miscellaneous

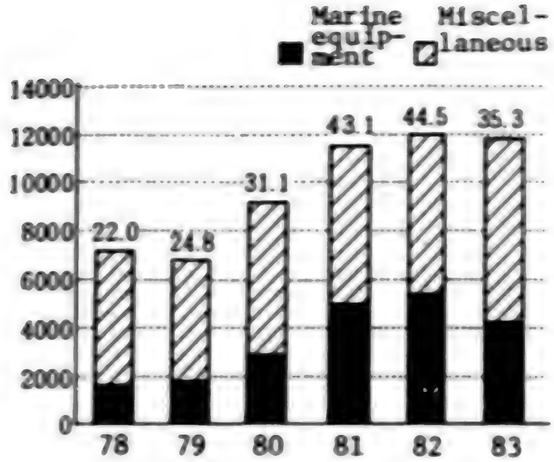


Figure 1. Trends of Ocean-Related Total Sales

Note: The figures on the bar graph show the ratio in percent of sales of marine equipment to those related to overall marine development.

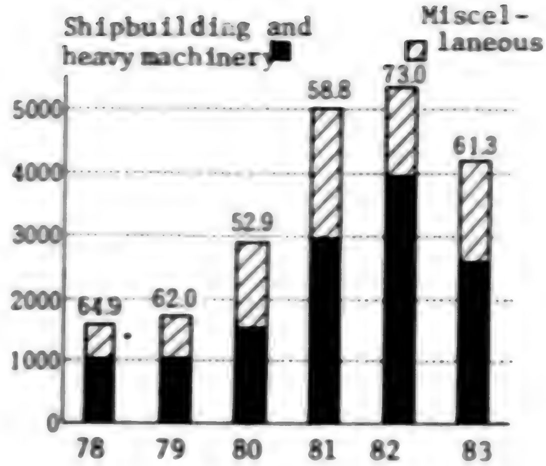


Figure 2. Trends of Total Sales of Marine Equipment

Note: The figures on the bar graph show the ratio in percent of shipbuilding and heavy machinery related sales to the total sales of marine equipment.

shipbuilding and heavy machinery accounted for ¥256.7 billion, down 66 percent over the previous year (see Figure 2). Sales by sector of marine equipment show that most sales are in the area of marine vessels in the research and observation sector, petroleum development supply vessels such as supply boats and production facilities in the submarine resources development sector, and those of offshore plants and vessels for marine construction in the marine space utilization sector. With regard to a share of sales by sector of marine equipment, as shown in Figure 3, the submarine resources development sector increased its share, while the total share of the sectors of research and observation, marine space utilization and water resources development decreased from 43 percent in FY 1978 to 15 percent in FY 1983. With regard to the sales by destination of marine equipment, as shown in Figure 4, those from the administration-private sector combined domestic demand account for 20-25 percent, those overseas 75-80 percent. Following is a general view of the trend of marine equipment by main sector.

(1) Marine bioresources (fisheries) have conventionally been secured sufficiently only by depending upon natural productivity. However, there is a sign of decrease recently in the absolute quantity of resources and fishing grounds have been limited due to setting up of 200-mile exclusive fishing zones by individual nations; realization that resources are not infinite has occurred. As a result, a shift from fisheries for harvesting to those of hatching is being made. In this sector, fisheries facilities and equipment such as an artificial fish-breeding ground, offshore aquaculture fish preserve, and breeding barges are likely to be positively used in a wide range of areas in the future.

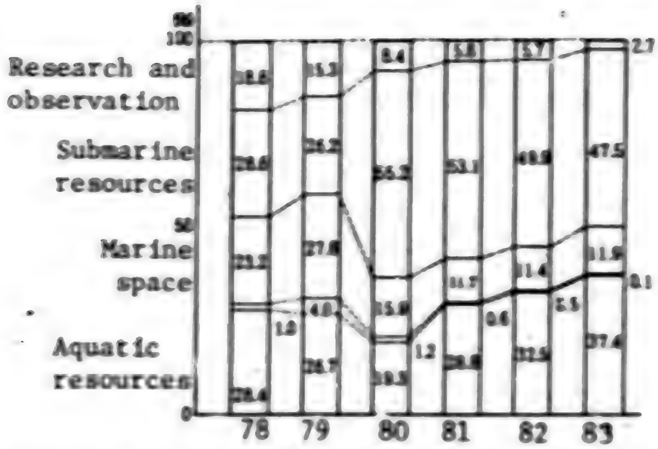
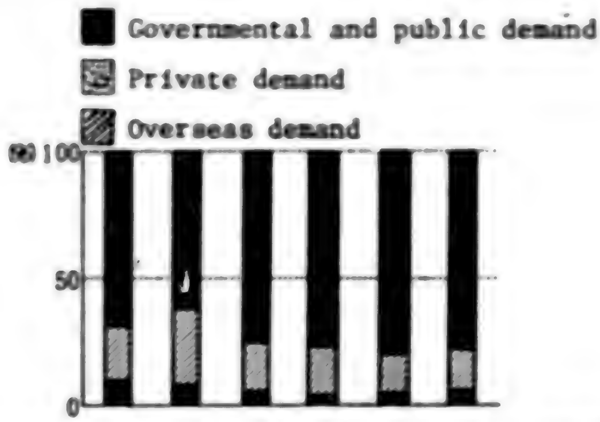


Figure 3. Transit of Sales Share by Sector of Marine Equipment



	1978	1979	1980	1981	1982	1983
Governmental and public demand	10.2	8.7	6.2	5.3	5.8	6.6
Private demand	21.2	29.7	19.3	18.6	15.0	16.2
Overseas demand	68.6	61.6	74.5	76.1	79.2	77.2

Figure 4. Transit of Sales Share by Destination of Marine Equipment

(2) Marine and Submarine Resources

Along with exhaustion of land oil fields, resources development shifted from land to sea areas, and recovery points in sea areas shifted from shallow to great-depth sea areas. Along with this, in Japan, too, a number of petroleum production drilling rigs, petroleum production platforms, and resources development auxiliary vessels (such as supply boats, etc.) came to be built, the number increasing rapidly since the oil crisis in 1973. In addition, from 1977 on modules have been built for offshore oil related facilities and a number of special carriers to carry heavy cargo such as a module jacket.

Worth watching recently is the building of petroleum drilling rigs with strengthening construction against the concrete rigs with excellent durability for use in the Antarctic sea area under harsh hydrographic and meteorological conditions. However, there has been a cutback in offshore petroleum development, which involves higher costs of land, caused by a recent drop in the crude oil price. The number of offshore petroleum related equipment built sharply decreased reaching its peak in 1981-82 (see Figure 5).

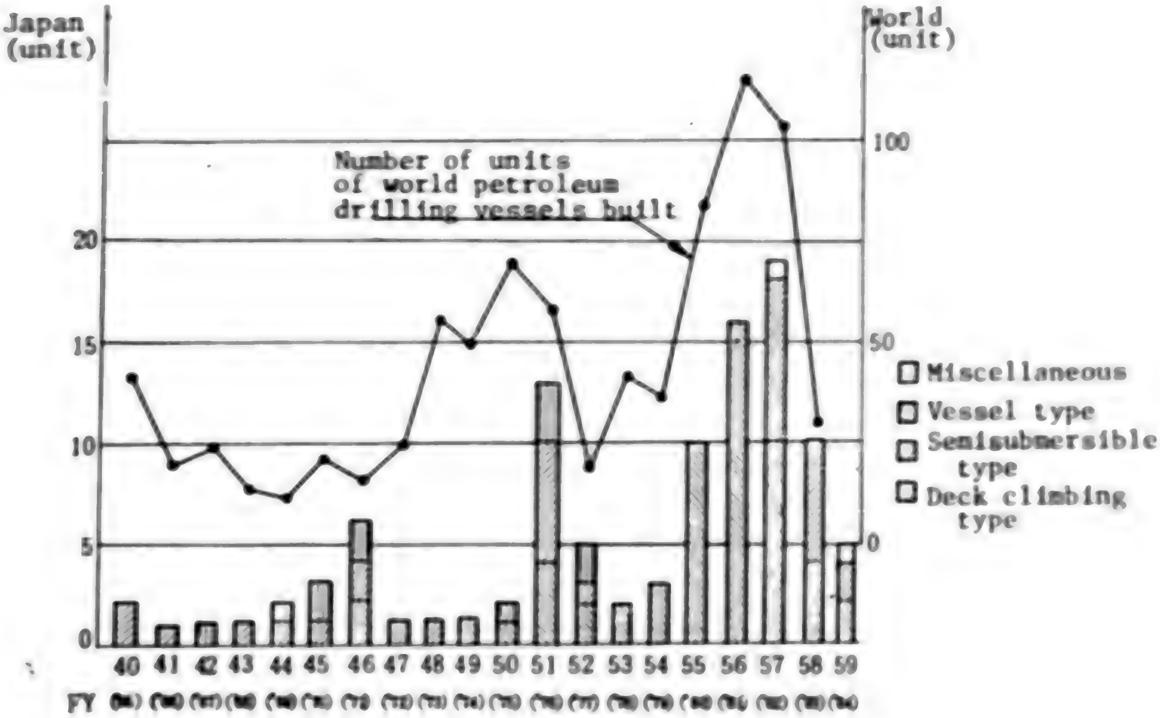


Figure 5. Trends in Number of Units of Petroleum Drilling Vessels (Rigs) Built

A medium-term outlook for world energy supply estimates the ratio of offshore petroleum to the entire petroleum production in the year 2000 at 35 percent, that of offshore natural gas to the entire natural gas production at 30 percent. In this context, building of petroleum drilling rigs and the like is expected to increase in the future, while the sideways movement in the building of offshore petroleum related equipment is likely to continue for the timebeing.

Starting in the 1960's and going to the first half of the 1970's, a great quantity of manganese nodules were discovered in succession, relevant scientific studies advanced, and their value as resources came to be recognized. It is well known that manganese nodules of good quality are widely distributed on the sea bottoms 5,000 m deep centering around Hawaiian Islands; studies of their probe, recovery, and refining methods are underway in Japan, too. Marine development is responding even to recovery of manganese nodules on deep-sea bottoms and mineral resources in hydrothermal deposits,

thanks to research and development of great-depth petroleum development technology and deep-sea scientific research technology, thus expected to result in development and building of a number of various, efficient mineral resources related equipment—survey instruments, offshore facilities, submarine facilities, etc.

(3) Marine Energy

In oceans, energy exists in the form of wave, current, temperature difference, and concentration difference and for efficient recovery of such energy, various forms of generating systems have been devised. However, present relevant technologies requiring higher generating costs compared with the existing generating systems have allowed marine energy utilization to make little progress; it is the case that sales of marine equipment in this sector remain extremely meager.

(4) Utilization of Sea Areas

Marine equipment for utilization of sea areas is targeted at facilities to make efficient use of marine space. Examples where equipment was built as facilities of this sector show that in many cases marine utilization is indispensable. This is the case with port facilities such as living facilities for petroleum drilling workers, plants (power generation, distilling, etc.) or storage facilities for remote areas, single point mooring buoys and floating piers. Submarine sightseeing towers and offshore restaurants so far built which can be referred to as positive "sea area utilization" are small in scale and few in number. Properly speaking, efforts should be made to export equipment for overseas markets such as living facilities, power and distilling plants, etc., but, regrettably, there is little demand for their building. From 1983 to 1984, a number of floating breakwaters were built. Those currently being built are small in scale, but expectations are placed on new demand for efficient use of calm sea areas to be created by enlarging their scale. Trends for the future are being watched.

(5) Miscellaneous

Building performance from 1976 to 1980 of marine research vessels to study hydrographic conditions, atmospheric phenomena, waves, currents, sea bottoms, distribution of planktons and that of temperature difference of seawater is in the upward trend, substantially increasing, notably from 1978 to 1980, due to orders for governmental and public vessels and those for economic cooperation made as part of shipbuilding slump countermeasures. However, they have been built only at the rate of six to eight every year.

Along with an increase in the volume of marine construction in the high growth period in the next decade beginning with 1965, a number of vessels for marine construction such as port facilities and bridge construction were built, followed by many ships for pipe laying and special operation and special carriers built for overseas markets early in the decade beginning with 1975.

The number of these vessels built from 1981 on has decreased, but together with progress in the development of the nation's coastal areas such as an offshore artificial island, renewed demand for them is expected in the future.

3. Conclusion

The great variety of type of marine equipment did not permit detailed description of a number of pieces of marine equipment to be mentioned in this article. However, it will serve those concerned as a source to grasp its trend. Incidentally, the "Main Marine Equipment Built in Japan" (a revised edition including FY 1984 additions) contains most pieces of Japanese-built main marine equipment. That book is recommended to those who are interested in the details.

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HUMAN FRONTIER SCIENCE PROGRAM'S AIMS DISCUSSED

Tokyo KOGYO GIJUTSU in Japanese Oct 86 pp 13-18

[Article by Kunio Nakajima, Director of Technical Research Division, Agency of Industrial Science and Technology]

[Text] 1. Introduction: The Agency of Industrial Science and Technology [AIST] has long discussed ways for Japan to contribute to the world in the field of science and technology. Being directed by prime minister Nakasone to "devise an international research cooperation plan," the Study Group on Technology and International Exchange (a roundtable which advises the AIST Director General, chaired by Seiichi Ishizaka, former AIST Director General) began consideration of the project in September, 1985. An interim report entitled "Technological Development and International Exchange for the 21st Century" was released last February; it proposed encouragement of a program of international basic research cooperation on technology for application of biological functions, the Human Frontier Program concept. The full report was carried in the February 1986 issue of this journal; this issue will present subsequent developments regarding this issue. (Now, the Human Frontier Program concept is presently under consideration within the government under the title "Human Frontier Science Program."

2. Background and Necessity: The Council for Science and Technology pointed out, in its 11th and 12th advisory reports, three issues as future directions of S&T policy: (1) enhancement and strengthening of creative basic research; (2) development of S&T in harmony with humanity and society; and (3) international development of S&T. The origin of the Human Frontier Program concept was a a continuation of that line of thought. Here is an outline of the background and necessity of the concept.

2-1. Limits of the conventional S&T system and creation of a new S&T system: Looking back at the long history of human society, we see that the industrial revolution, which arose in England from the second half of the 18th century through the 1830's, brought about unprecedented changes in social structure and laid the foundations of the present industrial society. Such production technologies as the steam engine, the spinning jenny, the boring machine, soda production and cement are products of that era; it can be called the first period of technical innovation among a flow of subsequent technical innovations. A second industrial revolution occurred, largely in America, in the late 19th and 20th centuries; this gave birth to many new industrial technologies including converter production of steel, wireless communications, the automobile, the diesel engine, the telephone, the phonograph, the

incandescant light and the airplane. It may be possible to give the name "3rd industrial revolution" to the period from 1925 to 1950 which produced a series of industrial technologies we enjoy today, including computers, commercial television, rocket engines, atomic energy, radar, synthetic rubber nylon and polyethylene.

If we refer to the accumulation over this long period of time as the conventional S&T system, we can say that the society we have built with it centers on machines, not humans, and is premised on the use of fossil fuels like oil, coal and natural gas. But looking at the society of the 21st century that awaits us, it is clear that we will face a variety of problems then.

First is the growth of world population. According to a United Nations survey of 1982, world population is to increase from 4.8 billion in 1985 to 6.1 billion in 2000 and nearly 8.2 billion in 2025. This growth in world population will make the world food shortage all the more severe. Because of increased use of fossil fuels and the environmental damage which accompanies human activity, the natural damage which is talked about even now will grow worse. And all the useful resources we use now-- not just fossil fuels-- will be depleted. How will we deal with problems like these?

Second is the aging of the population; this is a problem in the advanced countries especially. The increased proportion of aged within the overall population will require new employment opportunities for the aged, and improved productivity among the young in order to support society. The question of how to achieve this when there are no prospects for expansion of the world economy will be the key point in maintaining the vitality of society. In such a situation, science and technology can be expected to play a great role.

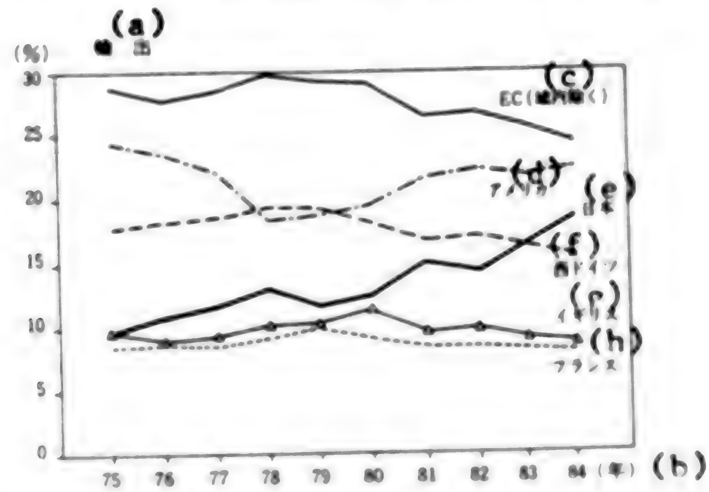
The third problem is that of expanding the realm of human activity and making that activity faster and more efficient. Mankind has already expanded its activity from land to the seas, the poles, to the air and to space. As these activities have been made faster and more efficient, new systems have been introduced and systems have been automated, enlarged and complicated, and they have become safer and more convenient. But new problems are also anticipated in that the burden on operators is growing, and possible damage in the event of an accident is immense.

Although mankind is pooling the wisdom of the world and seeking ways to solve these problems, the path we must follow will become more precipitous than ever if we adhere to the conventional S&T system. It is necessary to reexamine these problems from a new perspective. These problems have social, political and economic aspects, but should also be approached from the new perspective of science and technology, and handled with a new S&T system. But creating a new S&T system which is completely different from the conventional S&T system is not just a matter of revising and improving existing technology; it is necessary to approach them from a scientific base of pursuing principles and phenomena. Considering the time required to discover principles and to perfect technology, it is clear from our experience so far that we must begin now.

2-2. International contributions asked of Japan in the field of basic research: Japan is said already to have become "a country that accounts of 10% of the total world GNP." But that is largely the result of technology imports from Europe and the U.S. Since the Meiji era [1868-1912], Japan has imported technology from Europe and the U.S. in order to achieve rapid expansion of its national strength. Especially in order to rebuild its ravaged economy following WWII, Japan adopted the method of actively introducing the fruits of research in Europe and the U.S., and using it to develop new products. In this way Japan achieved reconstruction extremely efficiently and built up its present situation.

Japan's trade balance showed a surplus of $44.3 billion in 1984, and increased to $56 billion in 1985. If we look at the industrial manufactures which have sustained the expansion of the world economy, and the trade in advanced technology products which has made up a large share of that during the 1980's, we see that Japan has a large surplus in its trade balances with Europe and the U.S. (figure 1) [figure 1 not reproduced]. The trend of shares countries hold in the OECD statistics on trade in advanced technology products shows that the proportion of Japanese exports has increased year after year (figure 2). But in terms of investment (per capita) in basic research in government research institutions, U.S. spending is double Japan's, and West Germany's is four times Japan's. And the U.S., West Germany and France spend 7.3 times as much as Japan for basic research in universities. Japan's share in the technology trade balance has improved considerably recently, but it is only 0.34 in trade with the U.S., and 0.47 with France. Imports from the U.S. greatly exceed exports; at least as far technology trade is concerned, Japan can not be said to have been of much use to Europe and the U.S. Through 1985, there have been 4 Japanese recipients of Nobel prizes in the field of natural sciences, compared with 130 Americans and 62 British; this is an example of how little Japan has contributed in the field of basic research.

[Figure 2] Trend of shares of advanced technology products of major countries OECD trade statistics: proportion of each country's advanced technology product exports within the advanced technology product exports of all OECD countries (Source: OECD "B Statistics" cited in 1961 MITI White Paper)



[key on following page]

(a) Export
(b) (Year)
(c) EC (excluding trade within the community)
(d) U.S.
(e) Japan
(f) West Germany
(g) Britain
(h) France

This demonstrates that Japan, which ranks with Europe and the U.S. in terms of level of technology, has not yet made an adequate contribution to the development of science and technology, which holds the key to revitalization of the world economy. This is related to such things as insufficient internationalization of Japanese R&D activity, the rigidity of our system for accepting foreign students and researchers, the linguistic uniqueness of the Japanese language, Japan's geographical conditions and so on, but if this situation continues on as it has, we are in great danger of being isolated from the rest of the world. There are limits to economic development which relys, as Japan has so far, on introduction of technology from Europe and the U.S. It has become extremely important that Japan join the countries of Europe and the U.S. in taking up a role as a locomotive for the world economy. Consequently it is important that Japan voluntarily invest more people and capital in the field of basic research, and circulate the results widely through the world.

2-3. Fusion of technology and larger-scale, longer-term R&D: To this point we have referred to the necessity of creating a new S&T system. If we survey past technological innovations, we see that new technological breakthroughs arise from regions of fusion of existing technology. So the direction we are seeking is not in a given narrow field, but rather a broad field which bridges a number of fields. But because present research activity is very highly specialized, in order to bridge several fields it is necessary to mobilize many experts. This inevitably increases the costs greatly and extends the time period; Japan cannot implement such projects alone, so international cooperation has become necessary. This can be understood from the fact that America's SDA project and the European Eureka project require the participation of many countries, many researchers and large amounts of money. In other words, the "basic research program to create a new S&T" will have to be a project of global scale which brings together the wisdom of mankind, and of course one in which many countries participate over a long period.

3. Developments since the interim report: Since the interim report was released in February, MITI has had its concept examined in the Council on Science and Technology, the Study Group on Economic Structural Adjustment for International Cooperation and the Industrial Structure Council, and has exchanged views with experts of other countries in order to gain broad understanding of the concept in Japan and abroad. There has been very high praise for the basic idea, the topics, timing and setup for international promotion. But because the specifics of the project itself were not adequately firmed up and because there were many emergency items on the agenda, it did not become a topic at the Tokyo summit as originally intended. But in the Council on Science and Technology (chaired by the Prime Minister)

on 27 May, prime minister Nakasone directed that the project be pushed forward, and so it was decided that means of promoting it would be considered by the Council's Committee on Policy (chaired by former Kyoto University President Michio Okamoto). Then the 26 June meeting of the S&T Policy Committee approved initial procedures for the project, including implementation of a feasibility study under the fiscal 1986 Expenses for Promotion and Coordination of Science and Technology. How to carry out the feasibility is being studied at the working level now.

4. Outline of the Human Frontier Program: Paragraph 2-1 can be summarized as saying that, "our society was created by the conventional S&T system, but if we look ahead to the 21st century, we will face various problems. These problems should not be considered just in terms of their social, political and economic aspects; full consideration of the S&T aspect must be added. This study cannot be done just with the conventional S&T system; it is necessary to add in a new S&T system."

This "conventional S&T system" is essentially a system of engineering methods based on physics and chemistry. The system can be expected to develop further hereafter. But if it is possible to focus on the system of human thought, the autonomy and self-restoration capability of living bodies, and such functions as movement at normal temperature and pressure, digestion and adsorption, to explain these things and to realize engineering applications of them, then it will be possible to create an unprecedented new S&T system. That is, a new S&T system can be built by incorporating the new foundation of biology into present physics and chemistry.

4-1. Basic thinking for promotion of the program: Because of the background and necessity of the Human Frontier Program stated in paragraph 2, it is thought necessary to move the program forward in line with the following basic thinking: (1) close coordination among different fields using an international research system, and concentration of foreign and domestic wisdom; (2) an international contribution by Japan in the field of basic research, such as international circulation of the fruits of research; and (3) flexible operation of research to elicit maximum creativity from researchers.

4-2. Target research realms and method of approach: As stated at the beginning of this section, the realm of research to be covered by the Human Research Program is extremely broad, but centers on fields in which biology and medicine overlap with physics, chemistry and engineering. There are two approaches to this research. The "biological approach" is to explicate a biological function, feed the results back to the engineering side, propose hints for creating a model of the biological function, then recreate the function on the engineering side. The engineering approach" is to present the bilogical side with a specific task regarding a biological mechanism which cannot be recreated using traditional engineering methods alone, and thus urge creation of a model. Each of these approaches provides feedback to the other.

4-3. Specific topics: When a living body performs a function, there is always conversion or transfer of material and an accompanying conversion of energy. Thus all biological functions can be taken as functions of material and energy conversion. On the other hand, there are cases in which grasping

the result of the material and energy conversions as the manifestation of a function of information conversion is suited to the understanding of a higher biological function. It was decided, therefore, to consider biological functions under two topics-- conversion of material and energy and conversion of information-- and to bring the two together. Examples of these topics are shown in figures 3 through 5. The relationship with current biotechnology is as shown in figure 6, but where current biotechnology is a matter of using living organisms themselves, the technology to be researched under the Human Frontier Program is intended to use engineering means to realize the very functions possessed by organisms.

5. Conclusion: "Explaining the phenomenon of life and living functions and applying these to engineering" is certainly not a nonsensical concept in light of present S&T and the course of its future development; the expected development of mankind in the 21st century requires that we start on it now. But needless to say, this will take a long period, the participation of talented persons of all fields, and cooperation across national borders.

Meticulous planning based on an adequate grasp of the present situation is necessary, and it is essential that enough time be taken in the preparatory stages to build a consensus.

Since the February interim report was put together, understanding of its concept has been sought from all quarters. Fortunately the concept has been taken up by the entire government of Japan, and consideration of it has begun in the concerned ministries, with AIST serving as coordinator. We hope, therefore, it will be fully understood that the concept introduced here will change in the course of future domestic and international study.

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